UND CHESTER FRITZ LIBRARY
3 3100 00793 1057

NORTH DAKOTA GEOLOGICAL SURVEY
NIVERSITY, N. DAK.

Wis
WS11
QE
179
.A3
Period
Geol.

FIFTH BIENNIAL REPORT

OF THE

COMMISSIONERS

OF THE

Geological and Natural History Survey

Covering the period from
July 1, 1904, to June 30, 1906.

NORTH DAKOTA GEOLOGICAL SURVEY
LIBRARY
GRAND FORKS, N. DA

MADISON:
Democrat Printing Company, State Printer,
1906

W81

FIFTH BIENNIAL REPORT

OF THE

COMMISSIONERS

OF THE

Geological and Natural History Survey

Covering the period from
July 1, 1904, to June 30, 1906.

NORTH DAKOTA GEOLOGICAL SURVEY
UNIVERSITY, N. DAK.

NORTH DAKOTA GEOLOGICAL SURVEY
LIBRARY
GRAND FORKS, N. DAK.

MADISON:
Democrat Printing Company, State Printer,
1906

TABLE OF CONTENTS.

Page
Board of Commissioners 5
Staff of Survey 5
Letter of Transmittal 7
Report of the Superintendent of Survey 9
  I. Personnel of the the Survey 9
  II. Financial Statement 12
  III. Work of the Survey 13
    A. Investigation of the Lead and Zinc District 14
    B. Investigation of the Clays 14
    C. Areal Geology 15
    D. Lake Biology and Chemistry 21
    E. Physical Geography 23
    F. Underground Waters 24
    G. Water Powers 24
  IV. Publications 29
  V. Exhibit at Louisiana Purchase Exhibition 30
  VI. Plans for the future 31

Appendix:

Financial report from Secretary of State 36
Statutes of Wisconsin relating to the Survey 40
Publications of the Survey 43

GEOLOGICAL AND NATURAL HISTORY SURVEY.

BOARD OF COMMISSIONERS, 1904–1906.

ROBERT M. LAFOLLETTE,
Governor of the State, to January 1, 1906.

JAMES O. DAVIDSON,
Governor of the State since January 1, 1906.

CHARLES P. CARY,
State Superintendent of Public Instruction.

CHARLES VAN HISE,
President of the University of Wisconsin.

CALVERT SPENSLEY,
President of the Commissioners of Fisheries.

JOHN J. DAVIS,
President of the Wisconsin Academy of Sciences, Arts, and Letters, to February 8, 1906.

LOUIS KAHLENBERG,
President of the Wisconsin Academy of Sciences, Arts, and Letters, since February 8, 1906.

OFFICERS OF THE BOARD.

CHARLES R. VAN HISE,
President.

CHARLES P. CARY,
Vice-President.

JOHN J. DAVIS,
Secretary to February 8, 1906.

LOUIS KAHLENBERG,
Secretary since February 8, 1906.

JOHN J. KEMPF,
Ex-officio Treasurer.

PRESENT ORGANIZATION OF THE SURVEY.

BOARD OF COMMISSIONERS.

JAMES O. DAVIDSON,
Governor of the State.

CHARLES R. VAN HISE, *President,*
President of the University of Wisconsin.

CHARLES P. CARY, *Vice President,*
State Superintendent of Public Instruction.

CALVERT SPENSLEY,
President of the Commissioners of Fisheries.

LOUIS KAHLENBERG, *Secretary,*
President of the Wisconsin Academy of Sciences, Arts, and Letters.

STAFF OF THE SURVEY.

E. A. BIRGE, *Director of the Survey.*

S. WEIDMAN, *Geologist.*
Survey of Central and Northern Wisconsin.

W. O. HOTCHKISS, *Geologist.*
Economic Geology.

CHANCEY JUDAY, *Biologist.*
Biology of Lakes.

U. S. GRANT, *Geologist.*
Survey of Southwestern Wisconsin.

H. RIES, *Geologist.*
Clays of Wisconsin.

VICTOR LENHER, *Chemist.*
Chemistry of Lakes.

J. W. GOLDTHWAIT, *Geologist.*
Physical Geography.

R. C. BENNER, *Chemist.*
Chemistry of Lakes.

GEORGE WAGNER, *Biologist.*
Report on Fish.

CONSULTING GEOLOGIST.

T. C. CHAMBERLIN, *Pleistocene Geology.*

INVESTIGATION OF WATER POWERS.

L. S. SMITH, *Civil Engineer.*
Engineer in Charge.

V. H. REINEKING, *Assistant.*
D. H. DUGAN, *Assistant.*
In charge of Field Parties.

LETTER OF TRANSMITTAL.

Commissioners of the Wisconsin Geological and Natural
History Survey, Madison.

Office of the President.
December 24, 1906.

Honorable James O. Davidson,
Governor of the State.

Sir:—I have the honor to transmit herewith the report of Dr. E. A. Birge, Director and Superintendent of the Geological and Natural History Survey for the biennial period extending from July 1, 1904, to June 30, 1906, including also a general statement of the work performed by the Survey during the summer and fall of 1906. During this period the annual appropriation for the Survey has been $10,000, and the legislature of 1905 made a special appropriation of $2,500 for the investigation of the water powers of the State.

The report of the Director shows that several important pieces of work have been carried out during the biennial period: Professor Grant's report on the lead and zinc district has been completed and published; the report of Professor Ries on the clays of the State is now in the bindery and will shortly be issued; the report of Dr. Weidman on the geology of more than 7,000 square miles in the North Central part of the State is in press; the investigation of the lakes of the State has been carried on with more vigor than before and important results have been reached, both scientific and practical. The United States Geological Survey has coöperated with the State in the investigation of the water powers, contributing a sum equal to that furnished by the State. This work has been under the charge of Professor L. S. Smith, whose report is in course of preparation and will in due time be submitted to the legislature. In the spring of 1906 Mr. W. O. Hotchkiss was appointed economic geologist and devoted most of his attention to the study of the rural highways and the preparation of a preliminary report on that important subject. This is now in press and nearly ready to be issued.

These are the most important pieces of work which the Survey has accomplished during the biennial period although several minor investigations have been carried on, as is indicated in the report of the Director. The most important of these are Dr. Goldthwait's study of the physical geography of the Lake Michigan shore and the beginning of a collection of the fishes of the State by Mr. Wagner.

I would call attention to that part of the report of the Director regarding the opportunities of the Survey for enlarged work in the coming years. All of the subjects to which he calls attention are of great importance: the educational work for improving rural highways; the continuance of the investigation of the water powers; the extension of the survey of the lead and zinc district; and the beginning of coöperative work with the U. S. Geological Survey in the preparation of a topographic map of the southern part of the State.. The Commissioners trust that the legislature will make it possible for them to take up some or all of these important maters.

Very respectfully yours,
CHARLES R. VAN HISE,
President.

REPORT OF THE DIRECTOR OF THE SURVEY.

To the Commissioners of the Geological and Natural History Survey:

Gentlemen:—I submit herewith my report as Director and Superintendent of the Survey under your charge from July 1, 1904, to June 30, 1906. I include also a statement of the work of the Survey during the summer of 1906; thus giving an account of its operations up to the time when the report goes to press.

The income of the Survey during the biennial period has been $10,000 annually; the same as during the latter part of the period covered in the preceding report. By chapter 475 of the laws of 1905, the additional sum of $2,500 was appropriated for the investigation of the water powers of the state. This work has been carried on in coöperation with the U. S. Geological Survey which has contributed to the investigation a sum equal to that expended by the state.

I. PERSONNEL OF THE SURVEY.

The following persons have been in the employ of the Survey during the past two years with the compensation stated in each case. All persons who are paid by the year or month have been allowed their actual expenses while in the field, in addition to the compensation stated.

E. A. Birge, Director and Superintendent of the Survey—Compensation $500 annually.

T. C. Chamberlin, Consulting Geologist; without compensation except repayment of field expenses.

Samuel Weidman, Geologist in charge of areal geology—$1,400 per annum until May 1, 1906; $1,800 per annum since that date.

U. S. GRANT, Geologist in charge of lead and zinc region; paid at rate of $150 per month during the summer of 1904; compensation at the same rate afterwards, but only a small amount of work done.

HEINRICH RIES, Geologist, report on clays; compensation $150 per month during the summer of 1904, and at the same rate afterwards during the preparation of report.

F. L. GALLUP, Geologist, assistant to Professor Ries; salary $60 per month during the summer of 1904.

J. W. GOLDTHWAIT, Geologist, physical geography of the Great Lake region; salary at the rate of $75 per month; employed during a portion of the summer of 1905.

CHANCEY JUDAY, Biologist; salary $1,200 annually, since August 1, 1905.

GEORGE WAGNER, Biologist, report on fish; compensation $75 per month, not to exceed $300 during the year; employed for about two weeks during the summer of 1905 and for some two months in the summer of 1906.

VICTOR LENHER, Chemist; compensation at the rate of $5 per day; employed during part of summer of 1905 and occasionally thereafter.

R. C. BENNER, Chemist; $60 per month during the summer of 1905: $75 per month in 1906; assisted Professor Lenher in work on chemistry of lakes in 1905, and in charge of field work in chemistry in 1906.

W. O. HOTCHKISS, Economic Geologist since May, 1906; compensation $800 per annum for half time.

E. B. HALL, Geologist, field assistant to Dr. Weidman; compensation $40 per month, 1905; $65 per month, 1906; employed during summers.

J. H. WARNER, Geologist, assistant to Dr. Weidman summer of 1905; salary $50 per month.

L. S. SMITH, in charge of investigation of water powers; compensation at the rate of $6 per day.

V. H. REINKING, assistant to Professor Smith; compensation at the rate of $3 per day, in charge of party.

D. H. DUGAN, assistant to Professor Smith; compensation at the rate of $3 per day in charge of party.

Under the arrangement with the U. S. Geological Survey, most of the compensation of these persons was paid by that organization, while the money appropriated by the State was used in defraying expenses of the field parties during the summer and fall of 1905 and 1906. Professor Smith has received compensation at the rate of $6 per day from the general appropriation made for this Survey, while preparing a special report to be presented to the legislature.

Several assistants were employed by Professor Grant during the summer of 1904, whose names are given in the Fourth Biennial Report of this Survey. Mr. J. R. Banister was employed by the day occasionally during 1906 in securing data and completing reports from the lead and zinc region. Several assistants acted as rodmen and in similar capacities on the water power survey.

Besides the persons named above, others have been employed for special services and for short periods, as draftsmen, and in similar temporary capacities.

The names of all persons who have received money from the Survey, with the amount paid to each person, are given in the statement of expenses from the Secretary of State, which is appended to this report. In the case of those persons employed by the year or month, the sums indicated as paid to them include not only salaries but also all other payments to them, audited by the Secretary of State, including expenses while in the field and repayment of bills paid by them.

II. FINANCIAL STATEMENT.

In the following table, I have summarized the expenditures of the Survey according to departments, thus indicating the main directions in which the money, appropriated by the state, has been expended. The result is as follows:

	1904–1905	1905–1906	Total
Administration	$860.95	$810.77	$1,671.72
Areal Geology	2,748.25	2,913.32	5,661.57
Clays	3,155.09	319.41	3,474.50
Southwestern Wisconsin	3,618.25	540.31	4,158.56
Physical Geography	....	878.97	878.97
Economic Geology	....	210.03	210.03
Biology	1,008.88	1,891.10	2,899.98
Chemistry of Lakes	....	1,426.11	1,426.11
Report on Fish	....	103.28	103.28
Report on Underground Waters	....	228.45	228.45
Miscellaneous investigations	363.07	111.39	474.46
	$11,754.49	$9,433.14	$21,187.63
Water Powers	$1,250.01	$984.08	$2,234.09

The expenses for administration include Director's salary, $500, the pay of a clerk, $240, and expenses for stationery, printing, postage, freight and express, etc., which are not chargeable to special investigations. In each of the years covered by this report the Director spent the entire summer—about three months—in field and laboratory work associated with the biological investigations of the Survey, receiving no compensation for that work. Under miscellaneous investigations were included in 1904–05 the services of E. T. Hancock, as geological aid to the Forestry Commission for two months, and smaller payments for report on forest trees. The miscellaneous expenses for 1905–06 were payments on the forest tree report an dthe defraying of part expenses for investigation of the Polyporeae, a group of fungi infesting trees.

The sums as given in the statement above do not agree with the totals from the tables furnished by the Secretary of State. The figures in my report refer to claims audited at this office during the period covered by the report, and always include some claims at the close of the year not included by the Secretary of State, and omit at the opening of the year others included by him. The Secretary of State also includes in his report items paid from the general fund for printing and engraving.

III. WORK OF THE SURVEY.

When the legislature of 1903 increased the appropriation of the Survey to $10,000, it was understood that the first work undertaken through the aid of the increased income should be the Survey of the lead and zinc district of Southwestern Wisconsin and the investigation of the clays of the state. In pursuance of this understanding, Professor U. S. Grant carried on a careful survey of that region during the summers of 1903 and 1904, the results of which have been published as Bulletin No. XIV of this Survey.

In 1904 Professor Heinrich Ries of Cornell University, who is the foremost authority in the country on the subject of clays, was engaged to make a survey of the clay resources of the state and to prepare a report. Mr. F. L. Gallup was engaged as his assistant. The report was completed and will probably be issued from the press before the appearance of this biennial report.

Dr. Weidman's investigations of the geology of Central Wisconsin have been continued and his final report on the geology of a large area in that part of the state has been completed and is in press.

The completion of the field work on the lead and zinc district made it possible for the Survey to enlarge its investigation of the lakes in 1905, when Mr. Juday was called as biologist, and chemical work on the lakes was taken up, under the direction of Professor Lenher and Mr. Benner.

The investigation of the water powers, made possible by the special appropriation granted by the legislature of 1905, was taken up conjointly with the U. S. Geological Survey and placed in charge of Professor L. S. Smith. The field work has been carried on during the summers of 1905 and 1906 and a report has been prepared which will soon be presented to the legislature.

In 1905 Dr. J. W. Goldthwait of Northwestern University was engaged to prepare a report on the glacial beaches of the Lake Michigan shore. His report has been completed and is now in press.

These are the main lines of work which the Survey has carried on and a more detailed account of each of them is given in the following pages.

A. Investigation of the Lead and Zinc District. A full account of this work was given in the Fourth Biennial Report and need not be repeated here. The work was carried on under an arrangement with the U. S. Geological Survey by which that Survey undertook the preparation of a map and description of the Mineral Point quadrangle, and also a monographic account of the upper Mississippi lead and zinc district The latter work was done by Dr. H. Foster Bain, now State Geologist of Illinois. The Wisconsin Survey mapped the chief ore-bearing districts in Southwestern Wisconsin which had been developed up to 1904, and investigated their geology. This work was done under the direction of Professor Grant. His report and the accompanying maps were issued early in 1906 as Bulletin No. XIV of this Survey. The report of Dr. Bain, which constitutes a full and scientific presentation of the facts and theories concerning the ore deposits, is now in press and a special edition will be printed for use in Wisconsin.

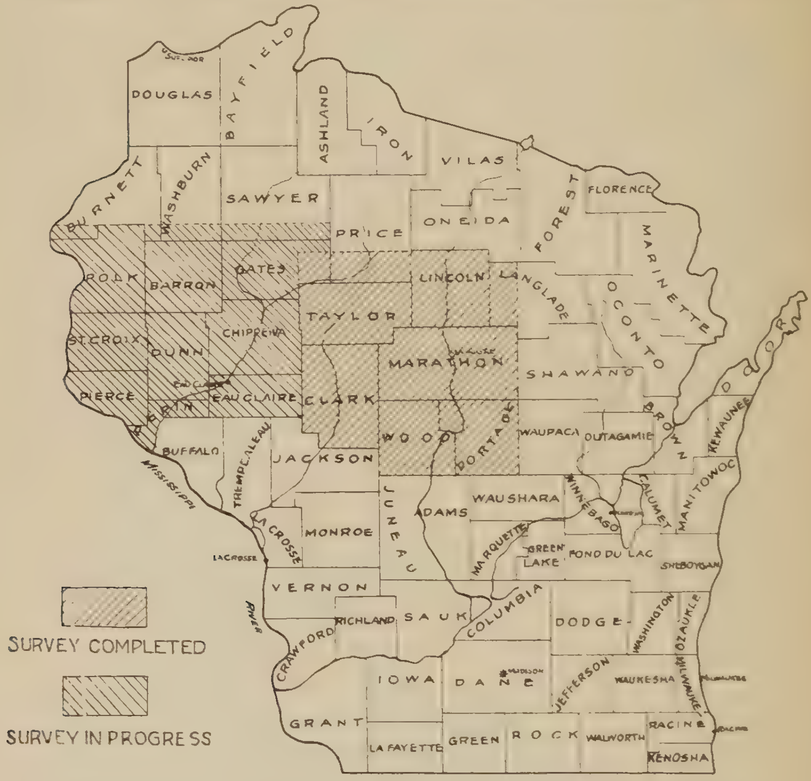
B. Investigation of the Clays. A general account of the work of Professor Ries was given in the last biennial report and need not be repeated. During the summer of 1905 Professor Ries, assisted by Mr. Gallup, completed the field work on the clays and the molding sands of the state. After the conclusion of the field season, he carried on the laboratory work on lines indicated in the last report. The manuscript of the bulletin, containing the results of his investigations, was received early in 1906 and was sent to the state printer in February of that year. At the present writing, December, 1906, it is nearly ready to be issued. It constitutes a bulletin of some 250 pages, with 30 plates.

Six years ago the Survey issued a report on the clays and clay industries of Wisconsin by Dr E. R. Buckley. In this bulletin the geology of the clays were discussed in some detail; a large number of clay analyses were included in the report and the clay manufacturing plants were described in detail. This bulletin was issued as Bulletin No. VII, Part 1, and it was intended to follow this by Part 2, containing the result of the physical and other tests on brick which were in progress but not completed when the bulletin was issued. Dr. Buckley's resignation from the Survey made it impossible to complete the work, which was taken up afresh by Professor Ries. His bulletin, therefore, contains a large number of physical tests, dealing with color, slaking, the effect of burning on the clays, their plasticity, tensile strength, shrinkage, etc., and tests of the brick for absorption, transverse strength, crushing strength, etc. There are also chapters on the origin and properties of clay, the methods of brick manufacture, and on the various uses to which the Wisconsin clays are put, or for which they are suited. The report on molding sand discusses the physical and chemical properties of molding sand and gives a detailed account of Wisconsin molding sands, together with sands from other districts used in Wisconsin.

C. Areal Geology. The survey of the central counties of the state is now completed and the geological report is in the hands of the state printer. This report should be ready for distribution in March or April, 1907. The area described in this report (see map, p. 16) designated North Central Wisconsin, includes Portgage, Wood, Clark, Marathon, Lincoln, and Taylor counties, with adjoining portions of Langlade, Price, and Rusk counties. The area comprises 201 townships, with an approximate extent of 7,200 square miles, about one-eighth of the state.

The report on the geology of the area contains a description of the general geology, the mineral resources and the physical geography.

The description of the geology is necessarily written from the scientific standpoint. The geological formations of the area range from the most ancient crystalline formations known in geology, to the newest glacial deposits. The crystalline formations include all the groups of igneous and also such metamorphic sedimentary rocks as quartzite, slate, and conglomerate. In carrying on the work of the survey every ledge of rock was examined, located on the section map, and specimens collected for study under the microscope or by chemical analysis. It is among the metamorphic sedimentary rocks that iron ores are likely to occur. In mapping the geological formations a number of occurrences of banded slate, the formation closely associated with the iron ores of the Lake Superior region, were found; while these occurrences of banded slate led to no discovery of iron ore in this area, their presence here is at least encouraging and seems to indicate the probability of other areas of slate and possibly of some iron ore in the unmapped portion of the State farther north.



Map showing location of North Central Wisconsin district.

The glacial drift of the area includes the deposits of drift of several distinct and widely separated glacial periods. In all, four drift formations, have been distinguished and mapped. While the mapping of the various drifts may at first sight appear to be of scientific interest only, it really has a great practical value, for the age and character of the drift largely determine the soil and agricultural conditions of the area.

The mineral resources include the various rock products of the area which have, or may have, an economic value. These include granite used for cemetery and building purposes, the sandstones used for building purposes, the deposits of quartz rock used as an abrasive and for other purposes, the various crystalline rocks suited for road material, the brick clays, the marl and peat deposits, and the water supply.

The physical geography of the area includes the description of the various land forms of the area and the history of their development. The report of the soils and agricultural conditions of the area was issued in 1903 as Bulletin XI.

During the last two years the general survey of the counties west of the north central part of the state has been in progress. This part of the state may be conveniently referred to as North Western Wisconsin. It includes (see sketch map) Eau Claire, Chippewa, Rusk, Barron, Dunn, Pepin, Pierce, St. Croix, and Polk counties, and parts of Sawyer, Washburn, and Burnett counties. It is planned to prepare a report of this area similar to that of the area farther east or North Central Wisconsin.

During the season of 1905 Dr. Weidman was assisted in the field survey by J. H. Warner and E. B. Hall. About four months was spent in field work, and part of Rusk, Sawyer, Barron, Chippewa, and Eau Claire counties was surveyed.

In 1906 Mr. Hall continued as field assistant, and about six months was spent in the field. The remaining parts of Eau Claire and Barron counties and the whole of Dunn county was surveyed.

During 1906 an informal coöperation in field work was carried out with Mr. Frank Leverett of the U. S. Geological Survey, in the survey of glacial formations. The survey of the glacial formations of the central part of the United States is under the general supervision of Prof. T. C. Chamberlin, who is also consulting geologist of the State Survey on glacial geology.

The stratigraphic position of the glacial formations of the several ice invasions of Wisconsin is not at present known and it is the plan of Prof. Chamberlin to have the formations occurring in central and western Wisconsin traced across Minnesota into Iowa and there correlated with the well described formations of the glacial series.

The United States Survey is at present occupied in the survey of the glacial formations of Minnesota. About one month was spent by Dr. Weidman in coöperation with Mr. Leverett in North Central and Northwestern Wisconsin, and along the Mississippi river in Minnesota. It is planned to continue in coöperation in 1907 or until the geology of the glacial series is determined.

D. Economic Geology. 1. *Work on Rural Highways.* The rapidly increasing recognition of the importance of good roads led Mr. Hotchkiss, upon his appointment in May, 1906, as economic geologist, to take up this subject as the one of most importance at the time. In starting this work a three-weeks' inspection trip was made through the southern half of the state, on which were inspected country roads in the counties of Washington, Sheboygan, Calumet, Winnebago, Waupaca, Portage, Wood, Clark, Trempealeau, La Crosse, Monroe, Crawford, Richland, Grant, Iowa, and Lafayette.

In order to secure detailed information from all parts of the state circular letters with lists of questions were sent out to all the town clerks in the state. Of the 1,150 town clerks 150 only did not reply to these requests. One of the requests sent out to town clerks was that they furnish the names of the most representative and intelligent farmers in their town. To 2,000 of these farmers another list of questions was sent and replies were received from about half. A list of names and addresses of all rural free delivery carriers was furnished by the Fourth Assistant Postmaster General, and still a different list of questions sent out to them. About 80% of the 1,450 carriers replied to these questions. From the replies to these circular letters a considerable amount of very valuable information was obtained which could have been obtained otherwise only at large expense. This information has been very carefully tabulated and is published in the bulletin on Rural Highways.

The bulletin on Rural Highways of Wisconsin is composed of two parts, the first dealing with the question of road location, construction, and maintenance, and the second part presenting a summary of the present conditions in Wisconsin, and having also a chapter summarizing the road laws of other states.

Part I contains the following chapters:—

(1) Essentials of a good road.
(2) Location of roads.
(3) Methods of road construction as applied to different kinds of soils, gravel and crushed stone.
(4) Road machinery.
(5) Road maintenance.
(6) Culverts and bridges.

Part II contains the following chapters:—

(1) Present highway conditions in Wisconsin. In this chapter are given the results obtained from the circular letters before mentioned, and a discussion of the good and bad points in the present highway system.
(2) Road laws and conditions in other states. In this is given a resume of the laws of states having the most progressive road legislation.
(3) Desirable changes in the present road system.
(4) A summary of the advantages to be gained by making the changes mentioned in chapter 3.

Copies of this bulletin have been sent upon request to the county superindentents for distribution to each country school. Copies have also been sent to each town clerk and each rural free delivery carrier. This wide distribution which has been thought advisable has necessitated the issue of a first edition of 17,000 copies.

It is hoped that this work may be carried on in a more extensive manner during the coming year. There is much that can be done to aid the people of the state in building themselves good roads, and for this purpose it is to be hoped that the legislature will grant the needed funds. In carrying on this work it would be necessary to secure the services of experienced road engineers to advise and assist the towns and counties in the construction of roads and bridges in the proper manner, and in the cheapest way consistent with good results. Public meetings for the instruction of road commissioners should be held in each county and pamphlets and literature regarding road construction should be distributed freely to all interested persons. The road materials of the State should be very thoroughly tested and a road school for the instruction of highway officers such as is already maintained by the Iowa Highway Commission should be held at Madison, somewhat after the plan of the two-weeks' farmers' course at present given by the Department of Agriculture. Such a road school should be held in coöperation with the College of Agriculture in order to avoid duplication of material. To secure more definite knowledge of the highway conditions of the State it is desirable that some preliminary sort of investigation should be made, such as a traffic census carried on during the course of a full year of a number of selected roads throughout the state.

2. In addition to the work on roads some attention has been paid to the lead and zinc district of southwestern Wisconsin in the endeavor to collect records of drilling for the purpose of aiding in extending the maps of the district. To aid in the collection of drilling records note books have been prepared for distribution to the drill men in which the records may be kept in good form. It is hoped that the drill men will be induced to keep better records by reason of having these books as a suggestion continually with them.

3. An investigation of the value for agricultural purposes of the feldspar occurring near Wausau, was begun in April,

1906. This occurrence of feldspar has been described by Dr. S. Weidman in a circular issued by the Survey. The feldspar of this locality contains about 8% of potash and it is possible that the potash occurs in sufficient quantity, and in suitable form, to be of value as a soil fertilizer. About two tons of the feldspar was collected, and ground to a very fine powder. The ground feldspar was then applied to some of the soil of the State experimental farms, and also to small samples of soils in the experimental laboratory of the State University. This experimental work has been done by Prof. A. R. Whitson and the laboratory tests already show favorable results. The results of the investigation of the farm soils under ordinary outdoor conditions will not be known for a year or two. This investigation has been in charge of Dr. Weidman.

D. Biology and Lake Investigations. The completion of the field work in the lead and zinc district and that for the clay investigation left the Survey free to undertake work in other directions, and part of the money was devoted to resuming the investigation of the lakes, which had been interrupted since 1901, when Mr. Juday resigned from the Survey. It was possible to reengage him as biologist and he resumed work in August, 1905. The Survey has been endeavoring to bring together a body of fundamental facts relating to the biology of lakes, which should ultimately aid in the solution of the practical problems of lake biology, as well as furnish a contribution to the scientific knowledge of this subject. One of the earliest pieces of work that the Survey undertook was the hydrographic survey of a considerable number of lakes in Southeastern Wisconsin. The investigation of lake temperatures was then carried on chiefly by the director without incurring any considerable expenditure of money from the Survey. It had been determined that the Survey should undertake as its next investigation, the determination of the dissolved gases of the water and the correlation of the life of the lake with these and with its temperature. This piece of investigation had long been planned by the Director and its general aims and methods had been determined by him.

With this purpose in mind, Professor Victor Lenher started some experimental work on the dissolved gases of Lake Mendota in the fall of 1904, with a view of deciding upon the best methods of investigation. The chemical work was carried on actively during the summer of 1905, under his direction and with Mr. R. C. Benner as chemical assistant. The Director took general charge and aided in the biological work until Mr. Juday began work with the Survey, when the latter took the responsibility for the collection and determination of the biological material. The field work was continued during the season of 1906 by Mr. Benner and Mr. Juday, with the assistance and under the general charge of the Director. The result has been that a very large body of facts has been brought together on this subject, constituting an investigation much more extensive than has ever been attempted on the subject. This material is now being worked up and put into shape for publication—a task which will occupy the remainder of the current fiscal year. It is intended to issue a report in three parts:

1. The morphometry of the lakes, including the hydrographic maps, with the areas, volumes, etc., of the lakes.
2. The lake temperatures, giving the results and conclusions from a long series of temperature observations which have been accumulated in the course of the work of the Survey.
3. The dissolved gases of the lakes, including the correlation of the animal and vegetable life of the open water of the lakes with the temperature and the dissolved gases.

A second line of biological work has been undertaken in co-operation with the Wisconsin Commissioners of Fisheries, namely: the collection of material for the preparation of a report on the fishes of the State. To this work Mr. George Wagner devoted a short time in the summer of 1905 and the greater part of the summer of 1906. He has collected from the streams and lakes of southern and eastern parts of the State and has brought together a large amount of material. The small amount of money at the disposal of the Survey for this work will necessarily make the collection of the fishes and the preparation of the report slow, but a fair beginning has been made and it is the intention of the Survey to prosecute the work steadily in the future.

In the fall of 1906 Trout lake, Vilas county, was visited by the biological staff of the Survey, with a view of attempting to correlate the distribution of the gases with that of the fish. It was found that the lower water of this lake, in which are found lake trout and a species of true whitefish, contains much larger quantities of oxygen than that of any other lake which has been investigated and which has a similar area and depth. It appears, therefore, that much knowledge of great economic importance may be obtained by studying the distribution of the fish, especially the lake trout and whitefish, in connection with the gases of the lower water. It appears also that the condition of the lower water as regards oxygen is mainly dependent on the amount of lower animal and vegetable life which the open water of the lake contains. The working out of these relations constitutes a piece of biological investigation of great importance, both from the scientific and the economic point of view.

A small amount of money has been granted by the Survey to Mr. J. J. Newman, in the defraying of expenses incurred in the preparation of a report on the Polyporeae—a group of fungi parasitic on trees. Most of this money has been expended in the preparation of photographs of the various forms of these fungi, to be used for illustrations in the report which he is to prepare for the Survey.

E. Physical Geography. The subject of the physical geography of the State has been necessarily neglected since the preparation of the report on the lakes of the state by Professor Fenneman. During the summer of 1905 Mr. J. W. Goldthwait of Northwestern University, Evanston, undertook the study of the elevated beaches of Lake Michigan. The field work was completed during that season and the report has been received and is now in press. It appears that these beaches show clearly the existence of several stages in the history of Lake Michigan since the glacial period and give evidence of a rise of the land increasing to the north. At Washington Island the highest beaches are now elevated about 100 feet above the level of Lake Michigan. The Survey was glad of the opportunity to do this piece of work, which is valuable and interesting in itself from a scientific and educational point of view and which was done in a district where the Survey has been able to carry on comparatively little investigation.

F. Underground Waters. Mr. A. R. Schultz had done most of the field work for a report on the underground waters of Wisconsin in connection with the U. S. Geological Survey. It was proposed that the work should be completed in connection with this Survey, the State undertaking the publication of the paper, which is of great interest on account of the relations of the underground water to artesian wells and city water supply. The paper was finished at small expense to the Survey and is now ready for publication. It will go to the printer as soon as the reports now in his hands have been completed.

G. Investigation of Water Powers. By chapter 475 of the laws of 1905 the legislature appropriated for the investigation of water powers during the biennial period just closed the sum of $2,500, with the understanding that the U. S. Geological Survey would coöperate in this work and would expend a sum equal to that appropriated by the State. The Director entered into a contract with the U. S. Geological Survey, embodying these general terms and with arrangements like those which have governed similar coöperative service in other states. The work was placed in charge of Professor L. S. Smith of the University of Wisconsin, who has executed it with great efficiency and with marked economy. He selected as chiefs of field parties Victor H. Reineking and D. H. Dugan, who have proved very capable and faithful assistants. Both began work in the late summer of 1905; Mr. Reineking taking up first the survey of the Black river, and Mr. Dugan the Wisconsin river from Kilbourn to Tomahawk. The parties were kept in the field until the close of the season of 1905 and during the season of 1906. All of the money specifically appropriated by the State and the National Government was expended on the field work and mapping, and the Survey has borne from its general funds the cost of the preparation of the special report for the legislature, which was called for by the statute authorizing the survey. Professor Smith has already prepared the greater part of this report, which will be submitted to the Governor for the use of the legislature at an early date.

When the law was passed under which this work has been done, it was planned to limit the survey to a general reconnoissance of our rivers, and examining those portions only which were of greatest importance as power producers.

The general specifications for the work as performed, however, were determined by the Federal authorities under the contract with them. These specifications required the field work to be of a much higher grade than had been expected. One specification, in particular, required that the topographic work should be controlled by accurate lines of wye levels, including the setting of standard, permanent, bench marks. This work alone has cost one-quarter of the entire $5,000 available for this work. This statement is not made for the purpose of criticising the specifications, for considering the demands of future power development, this extra cost is probably justified.

It seems also only just to the Federal authorities to state that, from the very beginning of the work, they have given Prof. Smith a free hand to change any of their general specifications, as he thought best. One of these changes has resulted in such a large saving in the State, without sacrificing any needed accuracies, that it may be briefly stated. On other similar, joint, state and Federal surveys, it has been the custom to run an accurate transit or meander line along the bank of the rivers. The points occupied by the transit were accurately marked by stakes and the direction or bearing of each line was noted, both looking forward and backward. This required all the stations to be occupied by the transit in order that the instrument might be properly oriented with respect to the meridian. This method secures great accuracy of location but it is too expensive for preliminary surveys of this character. Especially is this true of a state like Wisconsin, in which the magnetic needle is fairly reliable, when properly checked by stellar determinations. Accordingly, all the surveys have have been made with the "transit and stadia method," all directions being determined by the needle. This has increased the speed of the work by about one-third.

Before the opening of the University, Prof. Smith made reconnoissances of the entire length of the Black and Flambeau rivers which it was proposed to survey. The examination of the Flambeau river, between Park Falls and the mouth of the river, was in company with Dr. Weidman. Information regarding subsistence and transportation and other important matters was collected and, later, aided greatly in directing the field operations on these rivers.

The two field parties were not kept in the field all winter as it was not found economical to maintain parties in the field after the first of January. They were recalled and occupied part of the winter by preparing the map and profiles of the rivers surveyed.

The accompanying table shows in detail the work accomplished and its total and unit cost.

TOTAL AND UNIT COST OF WISCONSIN COOPERATIVE SURVEY, 1905-1906.

L. S Smith, Hydrographer.

River surveyed.	Spirit Leveling.			Topography.			Map and Profiles			Cost of reconnoissance and supervision per mile.	Total cost per mile of river.	Total cost.
	Total miles.	Total cost.	Cost per mile.	Total miles.	Total cost.	Cost per mile.	Total miles mapped.	Total cost.	Cost per mile.			
Wisconsin	187.3	$403	$2 16	197.0	$981	$4 97	197.0	$171	$0 89	$0 73	$8 61	$1,698 00
Eau Claire.....	0.0	0	0 00	25.8	177	6 87	25.8	11	0 44	1 00	8 29	213 80
Peshtigo.......	40.0	194	4 85	81.7	521	6 38	81.7	40	0 50	70	9 98	815 20
Black..........	69 3	213	3 10	63.0	213	3 38	63.0	57	0 81	1 00	7 99	552 30
Flambeau	102.0	467	4 58	119.5	796	6 69	119.5	106	0.81	1 25	12 71	1,519 00
Total	398.6	1,277	3 23 (Av.)	487.0	$2,688	$5 52 (Av)	487.0	$385	$0 79 (Av.)	$0 90 (Av)	$9 85 (Av.)	$4,798 30

Method:—Transit and stadia with wye level control.
Scale;—1 inch =1,000 feet.
Contour Interval=10 feet on land and 1 foot on water.
Section lines frequently located.

It is very noticeable that the cost of both topography and levels was much greater on rivers like the Flambeau and Peshtigo, which traverse wooded country devoid of roads. The average cost of the 398 miles of levels was only $3 23 per mile. The writer is not aware of any levels of this grade being run even in a built-up country for this price. As numerous permanent bench-marks were established at frequent intervals, this work will furnish the control of the regular United States Geological Survey topographic mapping of this area when it is executed. For this purpose it is well worth the entire sum furnished by the Federal government.

The 187 miles of levels along the Wisconsin river is referred to the Sea Level datum, as determined by the United States Geological Survey's precise level line between Milwaukee and La Crosse, while the Flambeau river levels are referred to the United States Army Engineers' Sea Level datum, through the United States Geological Survey's levels between the mouth of the Chippewa river and the mouth of the Flambeau river. The Peshtigo levels alone are based on the Chicago and Northwestern railway datum at Peshtigo.

The average cost of the topography alone is $5.52 per mile, and, combining the cost of levels, topography, mapping, and cost of supervision, the total cost per mile of river is $9.85. The United States Geological Survey authorities report that similar work has cost them $17.00 per mile, without *including cost of mapping.* The conclusion seems warranted that our Wisconsin work is the equal in execution of any similar work. It already has been officially approved by the United States Geological Survey officials. It is equally plain that the unit cost is about half that of similar coöperative work.

In addition to the river surveys discussed above and shown in the table, the following data have been secured on other rivers.

A complete profile of Milwaukee river, between its month and Kewaskum, a distance of 70.5 miles, has been secured at an expense of less than one dollar per mile. Advantage has been taken of the fact that the Chicago, Milwaukee and St. Paul and the Chicago and Northwestern railways occupy the valley of this river making necessary the running of only short lines from points on such railroads to the crest and foot of dams and other important points on the profile. A contour map of the river has also been prepared from the United States Geological Survey maps of this region at an expense of $10.

In a similar way and from data furnished by the United States Engineer Corps a complete profile of the Rock river has been prepared from Chester to the State line, a distance of 144 miles. It is planned to prepare a topographic map of this river also from the new United States Geological Survey map of this region. The total cost of this work on Rock river will not exceed $30.00. By similar means fairly accurate accurate profiles of the following rivers have been secured.

ADDITIONAL RIVERS WHOSE PROFILES HAVE BEEN DETERMINED.

[WITH SECONDARY ACCURACY.]

Name of river.	Miles.	Limit of survey.	Cost.	Remarks.
Catfish river	36	Lake Mendota to mouth.	$1 50	Levels by Hain and U. S. G. S. maps.
Beaver Dam river....	35	Fox Lake to.........	21 50	Levels by A. A. Fisher.
Oconomowoc river ...	30	Source to mouth	00	Levels by L. S. Smith, 1898.
Bark river	50	Source to mouth.....	00	Levels by L. S. Smith: U. S. G. S.
Fox river	131	Portage to Green Bay	00	Data, U. S. Eng'r officers.
St. Croix river	160	Mouth to source.....	00	Data, U. S. Eng'r officers.
Chippewa river	206	.... do .... do	00	U. S. G. S., 1898. U. S. Engineers, 1880.
Yellow river (St. Croix system.)	52	.... do .. do	00	do do do do
Clara-river........ ..	32	.... do .. Clam Falls.	00	do do
Namekagon river.....	70	.... do .. to source	00	do do
Totogotic river	50	.... do .... do	00	do do
Rib river	48	.... do .... do	00	U. S. G. S. and Ry's.
Yellow river	71	Marshfield to mouth.	00	Railroads.
Baraboo river.........	75	Elroy to mouth......	3 00	Levels, Wm. Kachel, and R'y.
Plover river...........	36	Mouth to Hatley	3 20	Levels, Geo. Grass, U. S. G. S.
Kickapoo river	70	La Farge to mouth..	00	C., M. and St. P. R'y.
Lemonweir river	47	Valley Jct. to mouth	00	Railroads.
Eau Pliene river......	37	Sec. 14, 27—2 E. to mouth.	00	U. S. G. S. map.
Red Cedar river	96	Source to mouth	00	O'Keefe and Orbison and R'y.
Menominee river	102	Twin Falls to mouth	00	Orbison: U. S. G. S.: R'y.
Sheboygan river	54	Source to mouth.....	00	Levels by J. Donehew: R'y.
Cedar creek.	31	do .... do	20 00	Levels by L. S. Smith: U. S. G. S.
Milwaukee river......	74	Kewaskum to mouth	50 00	Levels by L. S. Smith.
Rock river	144	Chester to state line.	20 00	RayOwen: U.S.G.Sf: R'y.
	1.741		119 20	

The object of these profiles hardly needs to be pointed out is two-fold:

1st,—To show the present developments.
2nd.—To point out the possibilities of future developments.

Of the larger Wisconsin rivers, the following remain to be surveyed:

(a) The St. Croix and its tributaries.
(b) The Upper Chippewa and its tributaries.
(c) The Upper Wisconsin and its tributaries.
(d) The Wolf River.
(e) The Oconto River.
(f) The Menominee River.
(g) The White and Bad Rivers.
(h) The Trempealeau River.
(i) The La Crosse River.

With the experience of the past year as a guide, it seems certain that future work can be done with even greater economy and that, too, without sacrificing any needed accuracy.

IV. PUBLICATIONS.

The publications of the Survey during this biennial period have included only two bulletins, although two others were in the hands of the state printer before the close of the period. The titles of the bulletins which have issued are as follows:

Bulletin No. XIII. Economic Series No. 8. The Baraboo Iron-Bearing District of Wisconsin. Samuel Weidman, Ph. D., Geologist Wisconsin Geological and Natural History Survey. 1904. Pp. IX, 190; 23 plates; including map of district; 3 figures in the text.

Bulletin No. XIV. Economic Series No. 9. Report on the Lead and Zinc Deposits of Wisconsin. U. S. Grant, Ph. D., Professor of Geology in Northwestern University. 1906. Pp. VIII, 100; 8 plates, including map of district; 10 figures in text; and atlas contaning 18 maps.

Bulletin No XIII was distributed in August, 1904. It includes a full and careful report of the geology of the Baraboo district, whose valuable iron deposits had just been discovered.

Bulletin No. XIV contains Professor Grant's final report on the geology of the lead and zinc deposits of Southern Wisconsin, together with a very careful atlas of 18 sheets, giving the geology and topography of the main ore-bearing districts. As mentioned on a former page of this report, Dr. Bain's bulletin, which will discuss especially the chemistry of the lead and zinc deposits, is to be published by the U. S. Geological Survey and has not yet been issued.

There are now (December, 1906) in press the following bulletins:

Bulletin No. XV. Economic Series No. 10. The Clays of Wisconsin and Their Uses. Heinrich Ries, Ph. D., Professor of Geology, Cornell University. With a report on Molding Sands, by H. Ries and H. L. Gallup. Pp. 247; 30 plates; 7 figures in the text.

Bulletin No. XVI. Scientific Series No. 4. The Geology of North Central Wisconsin. Samuel Weidman, Ph. D., Geologist, Wisconsin Geological and Natural History Survey. This bulletin will contain about 500 pages of text, with 100 plates and figures.

Bulletin No. XVII. Scientific Series No. 5. The Abandoned Shorelines of Eastern Wisconsin. J. W. Goldthwait, Ph. D., Assistant Professor of Geology, Northwestern University.

Bulletin No. XVIII. Economic Series No. 11. The Rural Highways in Wisconsin. W. O. Hotchkiss, B. S., Geologist, Wisconsin Geological and Natural History Survey. This bulletin will contain 135 pages; 16 plates; and 2 figures in the text.

V. THE EXHIBIT AT THE LOUISIANA PURCHASE EXPOSITION.

An account of this exhibit, for which $5,000 was allotted by the World's Fair Commissioners, will be found in the Fourth Biennial Report. Since the appearance of that report the awards have been formally made and are more important and numerous than was then indicated. The State of Wisconsin received a gold medal and a silver medal in recognition of the exhibit, and the Wisconsin World's Fair Commission a gold medal for the exhibit of building stones and clays. The Survey received four gold medals; awarded to the mine models, the exhibit of zinc ores and metallurgy, the general exhibit of mineral resources, and the publications of the Survey. Gold medals were also awarded to the Director, to Dr. S. Weidman, and to Dr. E. T. Hancock as collaborators. Silver and bronze medals were awarded as follows:

SILVER MEDALS.

Hazel Green Mining Co.	Hazel Green	Lead ore.
Marathon Granite Co	Wausan	Granite columns and cubes.
Milwaukee Monument Co	Monticello	Paving blocks and macadam.
Waukesha Imperial Water Co	Waukesha	Fox-Head trilithia water.
Ransom Manufacturing Co.	Oshkosh	Motor-driven emery grinder.
Ricketson Mineral Paint Works	Milwaukee	Mineral paints and mortar.
The Rock County Mineral Water Co.	Janesville	Blue Rock water.
Sheboygan Water Co	Sheboygan	Sheboygan water.
Allouez Mineral Spring Co	Green Bay	Allouez mineral water.
Anderson Bros. & Johnson	Granite Heights	Granite column, paving blocks.
Arcadian Lithia Water Co	Waukesha	Arcadian lithia water.
Bethesda Mineral Water Co	Waukesha	Bethesda water.
Chippewa Springs Co	Chippewa Falls	Chippewa Springs water.
W. H. Dudley	Madison	Views of Wisconsin scenery.
S. Weidman, C. F. Graff	Madison	Maps showing mineral resources and water power.

BRONZE MEDALS.

Wausau Sandpaper Co	Wousau	Crushed quartz and sandpaper.
Sampson and Ipsom	Edgerton	Pottery.

This recognition of the exhibit is peculiarly gratifying in view of the limited amount of money at the disposal of the Survey and the correspondingly small exhibit.

VI. PLANS FOR FUTURE WORK.

Several matters spoken of in the last biennial report have been undertaken. During the past two years the biological survey of the lakes has been carried on with much more vigor than in the past and excellent results have been reached. It is plain, however, that much larger gains could be made by the expenditure of a small amount of money in addition to that which the Survey has been able to afford. It ought to be possible to do more work on the fishes of the State and to correlate observations on these animals, which have so great economic importance, with the physical and biological conditions under which they live. As indicated on an earlier page, the study of the temperatures, the dissolved gases, and the plankton of the lakes is proceeding to a point where it is possible to utilize for economic ends the results thus reached, and the prosecution of the work will show whether it will not be practicable to determine the adaptability of the various inland lakes to the several forms of fish which are desirable either as food or for sport. In order to accomplish this, however, it will be necessary to make careful and extensive series of observations on the life of various species of fish, and to do this in connection with observations on the conditions of their life, similar to those which the Survey has been carrying on hitherto.

The study of the areal geology of the northern and northwestern portions of the state should be carried on in the future on the same scale as in the past until all of this region of the state has been carefully mapped.

In the direction of economic geological work large investigations are now of pressing importance and should be vigorously prosecuted by the State. The Survey has taken up the study of rural highways with the special design of informing the people of the State regarding more efficient methods of road construction. It seems plain that the money now expended on roads could yield better results if the expenditure is wisely administered and intelligently directed. In view, however, of the fact that the administration of highways is not centralized but widely scattered, a great amount of educational work must be done in order to bring to the people of the State even a rudimentary knowledge of these better methods. The Survey is in position to undertake this work, and I recommend that the Commissioners place this as among the items of first importance in the future enlargement of the work in economic geology. The bulletin of Mr. Hotchkiss, which will soon be issued and presented to the legislature, will show in brief and attractive form the needs of the rural highways and some of the methods by which these may be met. A summary of the work proposed for the next two years will be found on another page of this report.

There can be no question also but that the survey of the water powers of the State should be carried on and a somewhat larger sum of money should be appropriated for the next two years than was used in the past. The sum at the disposal of the Survey was not sufficient to maintain two field parties during the full season and to provide for the working up of the field notes and the preparation of the maps during the winter. The excellent results which Professor Smith has reached in the field work of the past two seasons have been made possible only by the most careful supervision and rigid economy. As the season's work was necessarily short much less has been done than would have been possible if funds had permitted the Survey to keep the parties in the field, when they had been trained for the work, as long as the weather would permit. The water powers of the State will be utilized very rapidly for commercial purposes and the survey should be pushed correspondingly. A sufficient sum should be given to maintain two parties in the field for the full season and to survey the rivers named on another page as of especial importance. I have no doubt that the U. S. Geological Survey will contribute to the investigation as much as the State provides.

Since Prof. Grant's maps of the lead and zinc district in Southwestern Wisconsin were issued mining and exploring for ore has extended rapidly beyond the areas which his maps cover. Important new districts have been developed of which there are no adequate geological maps to assist the drillmen and others in their search for ore. It is quite important that these maps should be extended to cover the areas so developed as the maps published have been found extremely useful. One mining engineer made the statement that he never saw a mining district in which the geological maps were so constantly in use by the mining men. The areas which need immediate attention and which should be earliest mapped are the Cuba City district betwen the Hazel Green and Platteville sheets; the district about Montfort—between Montfort and Livingston and north of the Mifflin sheet. Explorations have extended outside of the boundaries of the Dodgeville sheet and east and south of the Mifflin sheet. Two other important districts which have been developed recently are those about Lancaster and Beetown. While it may not be possible to cover all of these districts in a single year, plans should be made to cover them as soon as it is possible and such plans should fit in with a larger plan to map in this manner the whole of the intervening areas between the maps already published in which there is a possibility that ore deposits may be found. Of these areas mentioned the most urgent are the Cuba City and Lancaster districts.

The Commissioners should provide, at an early date, a definite plan for completing the topographic mapping of the State. This work has been done in a large number of states and has been found very useful for a variety of purposes. The following states are at present appropriating money for this purpose: Maine, Massachusetts, New York, New Jersey, Pennsylvania, Maryland, West Virginia, North Carolina, Alabama, Kentucky, Ohio, Indiana, Michigan, North Dakota, Oregon, and California.

It has been found possible to locate railroads and other engineering projects such as drainage and water power enterprises in a preliminary way, entirely by the use of such maps. Drainage engineers have found in them a most efficient aid in providing for the reclamation of marshy areas. This particular use is one which is rapidly becoming important, especially in the northern states in which large areas have been left in a condition unfit for agricultural purposes by the action of the glaciers which passed over the country ages ago. There are considerable areas in the central and northern parts of Wisconsin which will be among the most valuable agricultural lands in the State when some provision is made for draining them so that they can be cultivated. It it important for this purpose in Wisconsin that topographic maps be made which enable the careful planning of such drainage projects.

Besides these uses there are other secondary purposes which such maps serve. One of them is the relocating of country highways along more favorable lines in states where the movement for better highways has become active. Topographic maps also provide thoroughly reliable road maps for the use of wheelmen, automobilists and others traveling through strange territory. There is considerable call for these maps for use in this manner. Still another important use for topographic maps is for educational purposes in the school system of the state. The topographic maps represent in a very careful way the surface outline of the country and enable the schools which are located within the district so mapped to study in a most interesting manner the nature and origin of the various forms of land surface which exist in their neighborhood.

Wisconsin has never made any appropriation for topographical maps and the Commissioners have never asked the legislature for one, since other needs, apparently more pressing, have consumed all of the money which the legislature could be expected to appropriate. It is high time, however, that this work was undertaken, since there will unquestionably be a large demand for these maps long before they can be prepared. The preparation of a topographical map covering the areas which should be surveyed in Wisconsin will require a considerable number of years. The work should be undertaken in coöperation with the U. S. Geological Survey, as has been done in the other states referred to.

I have thus briefly indicated the lines in which it seems to me that this Survey can profitably serve the State. The funds at present at the disposal of the Commissioners are sufficient to provide for carrying on the work on the basis of the past two years, with the exception of the investigation of the water powers. If the new needs of the State in the direction of economic geology are to be met, it must be done by additional funds furnished by the State, and the amount of work which the Survey will be able to accomplish in these directions will depend on the action of the legislature.

Very respectfully submitted,

E. A. BIRGE,

Director.

APPENDIX.

FINANCIAL REPORT—FROM SECRETARY OF STATE—GEOLOGICAL SURVEY.

July 1, 1904—June 30, 1905.

American Express Co	$105 88	
Abercrombie & Fitch	36 02	
Andrews, C. W	13 35	
Blair, C. S	103 57	
Barrister, J. R	183 30	
Burling, L. D	12 86	
Brant, S. A	12 00	
Brewer & Penhallegon	104 70	
Birge, E. A*	1,026 91	
Brown, W. E	3 15	
Cox, G. H	103 03	
Cady, G. H	90 26	
Clark Eng. Co	238 51	
Chamberlain, T. C	27 79	
Cronk, T. B	8 10	
Cantwell Ptg. Co	31 25	
Dietzgen, Eugene	31 27	
Democrat Ptg. Co	1,075 94	
Davis, John J	26 39	
Dennister, R. H	53 18	
Daniels, W. W	22 00	
Ellis, E. E	41 40	
Esser, Agnes	71 63	
Fulcher, Gordon	283 16	
Gilbert & Cady	21 66	
Grant, U. S	974 52	
Gallop, Frederick L	789 43	
Grimm's Book Bindery	5 20	
Goldthwait, J. W	48 50	
Gurley, W. and L. E	5 25	
Hicks, James & Son	87 84	
Haak, Wm. J	11 50	
Harper, Blanchard	8 50	
Hopper, C. V	89 68	
Hancock, E. T	160 00	
Jones, T. H	5 40	
Jones, Mrs. Rose	46 45	
Kennedy, R	40 00	
Kelley, Park	17 25	
Lenher, Victor	752 15	
Lynch, P	8 00	

---

*Salary, expenses, and bills paid.

Lottrs, W. G	3 75	
Moes, E. S	22 75	
Merrill, H. B	20 00	
Moss, Jos. L	29 13	
Mautz Bros	7 10	
Middleton, Owen W	39 74	
Madison Tent & Awning Co	3 85	
Mann, T. H.	14 75	
Nicholas, J. W. & Co	43 14	
Ohms, Fred C. & Son	6 00	
Obert, E. G	50 70	
Perdue, M. J	470 75	
Patten, H. E	25 00	
Park, Wm. J	22 32	
Reed, Wm. J	90 24	
Ries, Heinrich*	1,933 56	
Spence, B. J	104 76	
Smithsonian Institution	36 50	
Smith, Warren D	101 70	
Stocker Geo	62 11	
Sanford, F. G	240 00	
Smith, L. S	30 98	
Spencer Lens Co	15 00	
Stephenson & Studemann	23 55	
Staley, Katherine	73 25	
Severin, Henry H	6 60	
Schultz, A. R	11 46	
Small & Stevens	12 00	
The Kny Scheerer Co	180 67	
The H. H. West Co	26 75	
Turner, J. D	12 40	
Tubesing, W. F	10 80	
U. S. Hotel	31 50	
Upfield, Jessie	21 00	
U. S. Express Co	63 12	
University Co-Operative Co	13 32	
Veatch, A. C	50 00	
Weidman, Samuel*	1,868 43	
Whiting, W. A	15 75	
Wis. Telephone Co	70	
Warren, Henry	75 45	
Wright, Rob't L	84 75	
		$12,732 31

---

*Salary and expenses.

July 1, 1905–June 30, 1906.

Hall, Edw. B., sal. & exp.	$467 16	
Ries Heinrich, sal.	339 71	
Ries, Heinrich, money advanced	64 30	
Warner, Julius H., sal. & exp.	287 07	
Weidman, S., sal. & exp.	2,049 28	
Wagner, Geo., sal. & exp.	103 28	
Staley, Katherine E., services	125 00	
Madison Boat Co., boat	26 25	
Reed, W. J., service and exp.	227 05	
Goldthwait, Jas. W., service and exp.	625 05	
U. S. Express Co., expressage	178 12	
Anderson, Albert, exp.	12 00	
University Co-operative Co., stationery	11 08	
Haak, Wm. J., hose	21 50	
Lenher, Victor, service and exp.	572 14	
Benner, R. C., service and exp.	721 98	
Wolf & Kubly, Mdse.	64 00	
Clark Engraving Co., cuts	111 55	
Mead, J. H., services	135 00	
American Express Co., expressage	226 36	
Sanford, Fannie G., services	220 00	
Birge, E. A., money advanced	544 05	
Juday, Chancey, services and expenses	1,397 53	
Stoelting, C. H. & Co., material	15 18	
Democrat Printing Co., printing	1,602 18	
Birge, E. A., sal. and exp.	410 15	
Denniston, R. H., services	75 00	
Grimm's Book Bindery, mounting maps	7 10	
The Kny-Scheerer Co., thermometers	12 50	
Pope Mfg. Co., supplies	7 34	
Kemmerer, Geo., services	12 50	
Bannister, J. R., services	380 95	
Grant, U. S., services	116 60	
Olive, Edgar W., expenses	8 92	
Spencer Lens, Co., supplies	15 00	
Schlimgen, Fred M., services	6 60	
Stevenson & Studemann, supplies	32 06	
Smith, L. S. services	125 86	
Tyrrell, Jos., shelves	31 20	
Chamberlain, L. C., exp.	30 15	
Hoen, A. & Co., maps.	2,540 50	
Harza, L. F., services	44 40	
Stumpf and Yaw, repairs	7 50	
Neuman, J. J., exp.	75 21	
Scheuer, Chas H., services	24 60	
Kuntze, Otto, services	3 13	
Severin, Henry H., services	47 70	
Kroncke, Bros., supplies	16 63	
Nielson, Edward Co., photographic work	9 00	
Hotchkiss, W. O., service and exp.	170 53	
Schultz, Alfred R., services	228 45	
Sargent, E. H. & Co., supplies	78 77	
North Western Litho. Co., maps	260 92	

Parker, E. E., services	14 03	
Davis, J. J., exp	9 13	
Sumner, E. & Son, supplies	10 50	
Wausau Quartz Co., supplies	15 00	
Cantwell Printing Co., stationery	35 00	
		$15,,009 75
Expenses under Chap. 475, Laws 1905:		
Claridge, Geo., services	$94 33	
Reineking, Victor H., services and exp	537 56	
Smith, L. S., services and exp	219 53	
Russell, Frank, services and exp	41 33	
Ball, Edw. M., services	29 33	
Kaley, Ed., services	41 33	
Dugan, David H., services	771 87	
Post, Frank F., services	81 00	
Abbott, H. S., services	32 00	
Stewart, F. P., services	9 33	
Stewart, G. C., services	9 33	
Owen, Ray, services	45 12	
Claridge, J. A., services	7 50	
Gaspard, I. C., services	81 00	
Long, M. B., services	81 00	
Parsons, H. H., services	6 67	
		$2,088 23

STATUTES OF WISCONSIN RELATING TO THE GEOLOGICAL AND NATURAL HISTORY SURVEY.

CHAPTER 297, LAWS OF 1897.

An Act to provide for the investigation of the natural resources of the state of Wisconsin, and providing an appropriation therefor.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. There is hereby constituted a geological and natural history survey of the state of Wisconsin.

SECTION 2. This survey shall have for its object:

(1) The completion of the geological survey of the state, and especially the examination of the rocks, with reference to the occurrence of iron ores, building stones, and other valuable mineral products, and in reference to their value as material for road construction.

(2) A study of the soils of the state.

(3 A study of the plants of the state, and especially of the forests, with reference to their cultivation and preservation.

(4) A study of the animal life of the state, and especially the occurrence, distribution and production of fish in the lakes and streams of the state, and a study of foods and enemies of fish.

(5) The preparation of an account of the physical geography and natural history of the state, in such form as to serve as manuals for the public schools, and of special reports on subjects of economic importance, in such form as to be of direct service to the people.

(6) The completion of the topographic map of the state begun by the United States Geological Survey; but no money shall be expended for topography unless an equivalent amount be expended for this purpose in the state by the United States government.

SECTION 3. This survey shall be governed by a board of commissioners, consisting of the governor of the state, the state superintendent of public instruction, the president of the state university, the president of the commissioners of fisheries, and the president of the Wisconsin academy of sciences, arts, and letters. The commissioners shall meet within thirty days after the passage of this act, and organize as a commission and adopt by-laws for their government, not inconsistent with law, and shall meet at such time and places as they may prescribe. A majority shall be a quorum. They shall receive no compensation, but each shall be reimbursed his expenses actually and necessarily incurred in the performance of his official duties, out of such appropriation as may be made by the legislature. They shall choose from their number a president, secretary, and such other officers as their by-laws may prescribe; but no officer shall receive any compensation, except such as is herein provided for. The commissioners shall have general charge of the survey, and shall appoint a superintendent of the survey, and, on his nomination, such assistants and employés as they may deem necessary. They shall fix the compensation of all persons employed in the survey, and may remove them at pleasure.

SECTION 4. It shall be the duty of the commissioners to prepare a report before the meeting of each legislature, showing the progress and condition of the survey, giving an account of money spent together with such other information as may be deemed necessary and useful. The superintendent shall transmit to the commissioners, from time to time, special reports, with necessary illustrations and maps, as these are completed. If approved by the commissioners, they shall be transmitted to the commissioners of public printing, who are authorized to have the reports published in a suitable manner, as independent reports, as bulletins of the state university, or in the transactions of the Wisconsin academy of sciences, arts, and letters, as the commissioners of the survey deem best. If published as independent reports, it shall be the duty of the commissioners of public printing to decide as to the number of copies in the edition of each particular report. Five copies of each report shall be delivered to each of the state officers, and to each member of the legislature. The number of copies provided by law for other public documents shall be furnished to the state historical society, the library of the state university, and other state institutions. The remainder of the independent reports shall be distributed, used in exchange, or sold by the commissioners of the survey, as the interest of the state and of science demands. All moneys obtained by the sale of the report shall revert to the state treasury, as a part of the general fund. Volumes obtained in exchange for the reports shall be added to the library of the Wisconsin academy of sciences, arts, and letters. The superintendent of public property shall furnish, upon the requisition of the president of the commissioners of the survey, such stationery and postage stamps as may be necessary for the use of the commissioners and the superintendent of the survey in official business.

SECTION 5. After material collected shall have served for the purposes of the survey, it shall be distributed to the state university, the colleges of state, the state normal schools, and the free high schools of the state, under the approval of the commissioners of the survey, in such a manner as to be of the greatest advantage to education in the state.

SECTION 6. There is hereby annually appropriated for two years to the commissioners of the geological and natural history survey, out of any money in the treasury not otherwise appropriated, the sum of $5,000, the first appropriation to be paid in the current fiscal year.

SECTION 7. This act shall take effect and be in force from and after its passage and publication.

Approved April 22, 1897.

CHAPTER 163, LAWS OF 1899.

An Act to appropriate a sum of money for the further prosecution of the geological and natural history survey of the state.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. There is hereby appropriated for the further prosecution of the geological and natural history survey, out of any money in the treasury not otherwise appropriated, the sum of ten thousand dollars annually for the term of two years. This money shall be expended by the commissioners of said survey for the purpose of executing the duties assigned to them by chapter 297 of the laws of 1897.

SECTION 2. This act shall take effect and be in force from and after its passage and publication.

Approved April 12, 1899.

CHAPTER 375, LAWS OF 1901.

An Act to appropriate a sum of money for the further prosecution of the geological and natural history survey of the state.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. There is hereby appropriated for the further prosecution of the geological and natural history survey, out of any money in the treasury not otherwise appropriated, the sum of five thousand dollars annually. This money shall be expended by the commissioners of said survey for the purpose of executing the duties assigned to them by chapter 297 of the laws of 1897, and any other duties which may be assigned to them by the legislature.

SECTION 2. This act shall take effect and be in force from and after its passage and publication.

Approved May 13, 1901.

CHAPTER 176, LAWS OF 1903.

An Act to appropriate money for the further prosecution of the geological and natural history survey of the state.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

Appropriation of $5,000 additional. SECTION 1. There is hereby appropriated for the further prosecution of the geological and natural history survey of the state, out of any moneys in the treasury not otherwise appropriated, the sum of five thousand dollars annually, in addition to the sum now appropriated by law. This money shall be expended by the commissioners of said survey for the purpose of executing the duties assigned to them by chapter 297 of the laws of 1897, and any other duties which may be assigned to them by the legislature, and especially for the investigation of the clays and clay industries and the completion of the survey of the lead region.

SECTION 2. This act shall take effect and be in force from and after its passage and publication.

Approved May 6, 1903.

CHAPTER 475, LAWS OF 1905.

An Act to provide for ascertaining the amount of available water power in this state and making an appropriation therefor.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. The geological and natural history survey of the state of Wisconsin is directed to cause survey to be made of the water powers of the state for the purpose of ascertaining the amount of available water power in this state, developed and undeveloped, and the location of the same. Such work may be done in conjunction with the United States geological survey. Upon the completion of such survey a full report thereof shall be made to the governor for the use of the legislature. The sum of two thousand five hundred dollars or so much thereof as may be necessary is hereby appropriated out of any money in the treasury not otherwise appropriated, to defray the expense of such survey.

SECTION 2. This act shall take effect and be in force from and after its passage and publication.

Approved June 20, 1905.

PUBLICATIONS

OF THE

Wisconsin Geological and Natural History Survey.

The publications of the Survey are issued as (1) bulletins, which are numbered consecutively, (2) biennial reports, and (3) hydrographic maps. These publications are independently paged and indexed, no attempt being made to group them in volumes.

1. BULLETINS.

The bulletins are issued in three series:

Scientific Series.— The bulletins so designated consist of original contributions to the geology and natural history of the state, which are of scientific interest rather than of economic importance.

Economic Series.— This series includes those bulletins whose interest is chiefly practical and economic.

Educational Series.— The bulletins of this series are primarily designed for use by teachers and in the schools.

The following bulletins have been issued:

Bulletin No. I. Economic Series No. 1.

On the Forestry Conditions of Northern Wisconsin. Filibert Roth, Special Agent, United States Department of Agriculture. 1898. Pp. vi, 78; 1 map. *Out of print.*

Bulletin No. II. Scientific Series No. 1.

On the Instincts and Habits of the Solitary Wasps. George W. Peckham and Elizabeth G. Peckham. 1898. Pp. iv, 241; 14 plates, of which 2 are colored; 2 figures in the text. Sold at the price of $1.50 in paper and $2.00 bound

Bulletin No. III. Scientific Series No. 2.

A Contribution to the Geology of the Pre-Cambrian Igneous Rocks of the Fox River Valley, Wisconsin. Samuel Weidman, Ph. D., Assistant Geologist, Wisconsin Geological and Natural History Survey. 1898. Pp. iv, 63; 10 plates; 13 figures in the text. *Out of print.*

Bulletin No. IV. Economic Series No. 2.

On the Building and Ornamental Stones of Wisconsin. Ernest Robertson Buckley, Ph. D., Assistant Geologist Wisconsin Geological and Natural History Survey. 1898. Pp. xxvi, 544; 69 plates, of which 7 are colored, and 1 map; 4 figures in the text. Sent on receipt of 30 cents.

Bulletin No. V. Educational Series No. 1.

The Geography of the Region About Devil's Lake and the Dalles of the Wisconsin, with some notes on its surface geology. Rollin D. Salisbury, A. M., Professor of Geographic Geology, University of Chicago, and Wallace W. Atwood, B. S., Assistant in Geology, University of Chicago. 1900. Pp. x, 151; 38 plates; 47 figures in the text. *Out of print.*

Bulletin No. VI. Economic Series No. 3. Second Edition.

Preliminary Report on the Copper-bearing Rocks of Douglas county, and parts of Washburn and Bayfield counties, Wisconsin. Ulysses Sherman Grant, Ph. D., Professor of Geology, Northwestern University. 1901. Pp. vi, 83; 13 plates. Sent on receipt of 10 cents.

Bulletin No. VII. Economic Series No. 4.

The Clays and Clay Industries of Wisconsin. Part I. Ernest Robertson Buckley, Ph. D., Geologist, Wisconsin Geological and Natural History Survey. 1901. Pp. xii, 304; 55 plates. Sent on receipt of 20 cents.

Bulletin No. VIII. Educational Series No. 2.

The Lakes of Southeastern Wisconsin. N. M. Fenneman, Ph. D., Professor of General and Geographic Geology, University of Wisconsin. 1902. Pp. xv, 178; 36 plates; 38 figures in the text. *Out of print.*

Bulletin No. IX. Economic Series No. 5.

Preliminary Report on the Lead and Zinc Deposits of Southwestern Wisconsin. Ulysses Sherman Grant, Ph D., Professor of Geology, Northwestern University. 1903. Pp. viii, 103; 2 maps; 2 plates; 8 figures in the text. *Out of print.*

Bulletin No. X. Economic Series No. 6.

Highway Construction in Wisconsin. Ernest Robertson Buckley, Ph. D., State Geologist of Missouri, formerly Geologist, Wisconsin Geological and Natural History Survey. 1903. Pp. xvi, 339; 106 plates, including 26 maps of cities. Sent on receipt of 30 cents.

Bulletin No. XI. Economic Series No. 7.

Preliminary Report on the Soils and Agricultural Conditions of North Central Wisconsin. Samuel Weidman, Ph. D., Geologist, Wisconsin Geological and Natural History Survey. 1903. Pp. viii, 67; 10 plates, including soil map. Sent, paper bound, on receipt of 10 cents; cloth bound, 20 cents.

Bulletin No. XII. Scientific Series No. 3.

The Plankton of Lake Winnebago and Green Lake. C. Dwight Marsh, Ph. D., Professor of Biology, Ripon College. 1903. Pp. vi, 94; 22 plates. Sent, paper bound, on receipt of 10 cents; cloth bound, 25 cents.

Bulletin No. XIII. Economic Series No. 8.

The Baraboo Iron-bearing District of Wisconsin. Samuel Weidman, Ph. D., Geologist, Wisconsin Geological and Natural History Survey. 1904. Pp. x, 190; 23 plates, including geological map. Sent, paper bound, on receipt of 10 cents; cloth bound, 20 cents.

Bulletin No. XIV. Economic Series No. 9.

Report on Lead and Zinc Deposits of Wisconsin. Ulysses Sherman Grant, Ph. D., Professor of Geology, Northwestern University. 1906. Pp. ix, 100; 8 plates; 10 figures in the text; and an atlas containing 18 maps. Sent on receipt of 20 cents.

Bulletin No. XV. Economic Series No. 10.

The Clays of Wisconsin and Their Uses. Heinrich Ries, Ph.D., Assistant Professor of Economic Geology, Cornell University. 1906. Pp. xii, 259; 30 plates, including 2 maps; 7 figures in text. Sent on receipt of 18 cents.

Bulletin No. XVIII. Economic Series No. 11.

Rural Highways of Wisconsin. W. O. Hotchkiss, B. S., Instructor in Geology, University of Wisconsin; in charge of Economic Geology, Wisconsin Geological and Natural History Survey. 1906. Pp. xiv, 135; 16 plates; 2 figures in the text. Sent on receipt of 10 cents.

In Press.

XVI. The Geology of North Central Wisconsin. Samuel Weidman, Ph. D., Geologist, Wisconsin Geological and Natural History Survey.

XVII. The Abandoned Shore-lines of Eastern Wisconsin. J. W. Goldthwait, Ph. D., Assistant Professor of Geology, Northwestern University.

2. Biennial Reports.

The Survey has published five biennial reports, which relate to administrative affairs only and contain no scientific matter.

First Biennial Report of the Commissioners of the Geological and Natural History Survey. 1899. Pp. 31.

Second Biennial Report of the Commissioners of the Geological and Natural History Survey. 1901. Pp. 44.

Third Biennial Report of the Commissioners of the Geological and Natural History Survey. 1903. Pp. 35.

Fourth Biennial Report of the Commissioners of the Geological and Natural History Survey. 1904. Pp. 42.

Fifth Biennial Report of the Commissioners of the Geological and Natural History Survey. 1907. Pp. 45.

3. Hydrographic Maps.

There have been prepared hydrographic maps of the principal lakes of southern and eastern Wisconsin. This work is in charge of L. S. Smith, C. E., Associate Professor of Topographic and Geodetic Engineering, University of Wisconsin.

The maps are as follows:

		Size of Plate, Inches.	Scale, Inches per mile.	Contour Interval, Feet.
No. 1.	Lake Geneva	17.5x10.8	2	10
No. 2.	Elkhart Lake	15.5x13.1	5	10
No. 3.	Lake Beulah	22.5x20.0	6	10
No. 4.	Oconomowoc-Waukesha Lakes	29.8x19.1	2	10
No. 5.	The Chain of Lakes, Waupaca	21.7x20.6	6	10
No. 6.	Delavan and Lauderdale Lakes	22.5x16.8	4	10
No. 7.	Green Lake	26.0x17.8	3.2	20
No. 8.	Lake Mendota	23.7x19.5	6	5
No. 9.	Big Cedar Lake	18.0x13.5	2.9	10
No. 10.	Lake Monona	17.6x17.3	4	5

In all of these maps the depth of the lakes is indicated by contour lines, and by tints in all except No. 1. They are sent on receipt of 15 cents each, except Nos. 4 and 8, for which 20 cents are required. They may be had either mounted in a manilla cover, or unmounted.

All correspondence relating to the Survey should be addressed to

E. A. Birge, *Director*,
Madison, Wis.